Tephrostratigraphy of Limagne revisited. Implications for Late Glacial and Holocene Prehistory.

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Juillet 2001

TEPHRAS

chronologie
chronology

archéologie
archeology

sous la direction de E. Juvigné et J.-P. Raynal

édité avec le concours de la région Auvergne et du Conseil Général de Haute-Loire

les dossiers de l'Archéo-Logis n°1

CDERAD éditeur - 43150 Goudet

Tephrostratigraphy of the Limagne revisited. Implications for Late Glacial and Holocene Prehistory

Un cadre tephrostratigraphique réactualisé pour la préhistoire tardiglaciaire et holocène de la Limagne (Massif central, France)

Gérard Vernet[1] et Jean-Paul Raynal[2]

Abstract: *from the Older Dryas to the Atlantic Period, ten pyroclastic formations originating from trachyandesitic and trachytic eruptions covered the plain of the Limagne d'Auvergne and have been preserved in various depositional contexts. They are useful isochronic markers for archaeologists examining their impact on prehistoric behaviours and settlements.*

Keywords: *tephras, Late-Glacial, Holocene, Limagne, Massif Central, Prehistory*

Résumé : *dix recouvrements de tephras, suffisamment importants pour avoir été préservés en stratigraphie dans des environnements sédimentaires divers, ont affecté la Limagne du Dryas ancien à l'Atlantique. Ils caractérisent des éruptions pour l'essentiel à magmas trachyandésitiques et trachytiques. Outre leur rôle incontestable de marqueurs isochroniques, ils incitent à reconsidérer l'impact du volcanisme de la Chaîne des Puys sur l'environnement des peuplements préhistoriques contemporains.*

Mots-clés : *tephras, Tardiglaciaire, Holocène, Limagne, Massif Central, préhistoire*

Following preliminary research (Brousse *et al.*,1969 ; Baudry et Camus, 1972 ; Camus, 1975) and a detailed synthesis based on a pluridisciplinary approach (Vernet,1992), the tephostratigraphy of Limagne has been completed (Vernet *et al.*, 1998) and detailed, identifying ten markers which are characterized by their facies, chemistry (in SiO_2/Na_20+K_2O diagram) (Le Bas *et al*, 1985) (figure 1), heavy mineral content and granulometry (Fischer, 1961). They have been directly TL dated or are associated with palaeosoils dated by radiocarbon, or occur within palynological sequences. From the oldest to the youngest, the identified tephras are :

1 - The *Cellule Tephra.* This is a coarse ash composed of trachyandesite, observed at Cellule within the Orange marsh and dated by palynology to the Ancient Dryas (Vernet and Paquereau, 1986, 1991 ; Vernet *et al.*, 1990). The mineralogical association is dominated by a green clinopyroxene (94.5%). It is strongly deformed by frost (figure 2), but one can estimate its thickness to be between 0.20 and 0.30 m. The source volcano is probably the Puy de La Nugère, during one of the oldest eruptive phases.

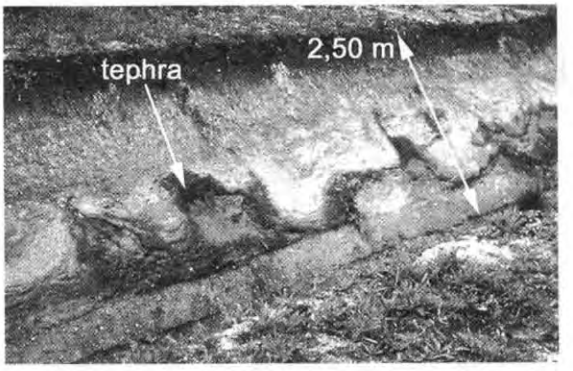

Figure 2: *the Cellule Tephra deformed by Late Glacial frost action at Cellule stratotype (photo G. Vernet).*

2 - *CF1a/ CF1b Tephric Complex* (La Barre Street fallout/ Les Roches fallout). About thirty observed sites distributed in the Limagne show that this is composed of a black basal level more or less developed (CF1a or La Barre Street fallout) followed by an upper grey level (CF1b or Les Roches fallout) (figure 6).

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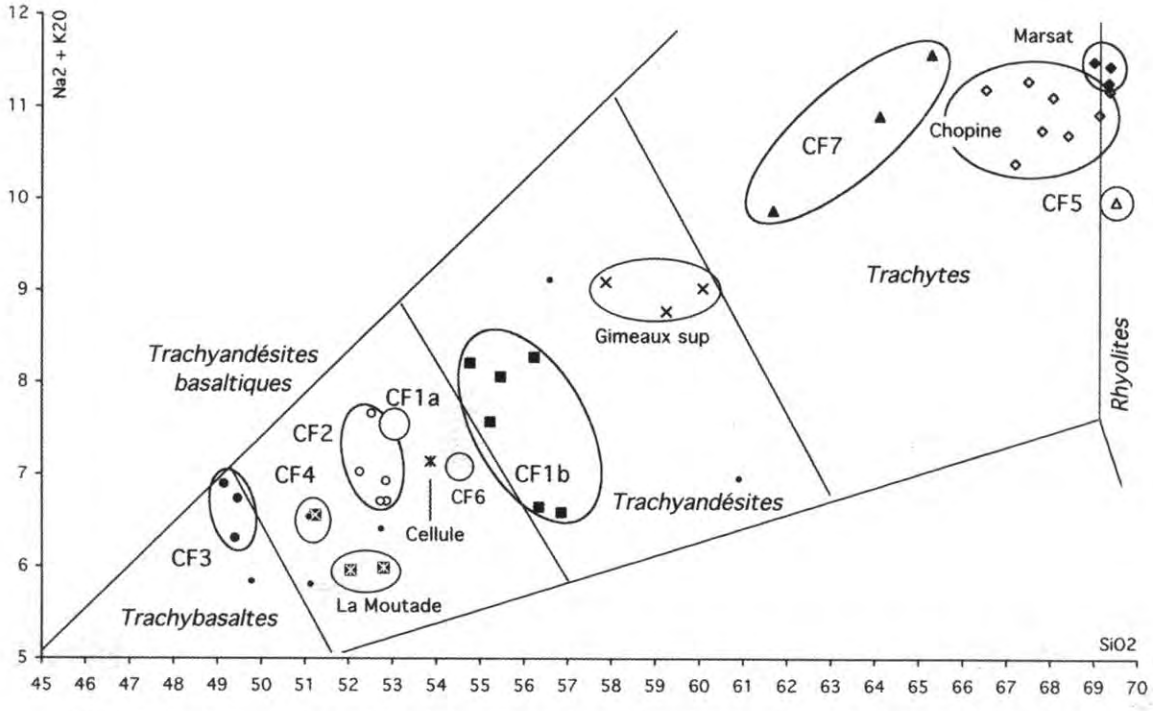

Figure 1: *chemical composition of identified tephra in SiO_2/Na_20+K_2O (weight%) diagram (after Le Bas et al., 1985).*

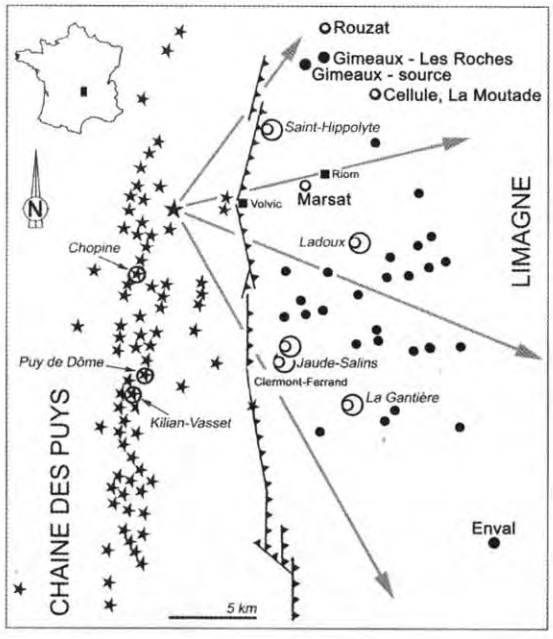

Figure 3: *observation of CF1 Tephra in Western Limagne (black dots) within the volcanic regional context : Chaîne des Puys volcanoes (black stars) with some major trachytic domes citated in text (star circled) and Limagne basaltic maars (circled crescents). Minimum extension of the eruptive plume coming from Puy de la Nugère and responsible of CF1 Tephra dispersion is shown by grey arrows. Some other tephra stratotypes noted (circles).*

CF1a, composed of basaltic trachyandesite, presents a facies in centimetric regular black beds grinding the existing topography with a basaltic composition. Its extension is less important than in CF1b : the observed sites are confined to the Clermont Basin (La Barre Street, Montjuzet Street, Blanzat Street) as well as in Gerzat-Cebazat and Le Brezet areas.

CF1b is bedded, with more or less thick lamina, composed of trachyandesite with brown amphibole as a characteristic mineral. It is composed of material accumulated in channels where intersected stratification can appear.
The facies are present in several stratigraphies in the Clermont (La Barre Street, Montjuzet Street...), in the Grande Limagne, in the Morge area (Gimeaux) and in the Magdalenian prehistoric site of Enval (figure 3). This covering has therefore been widespread in the Limagne and its average thickness is around 0.15m. A rapid calculation shows that 1500 m3 ashes per hectare have covered the Limagne around 12000 years BP. Its impact on the biotopes is evidenced by the palynology (D. Vivent, unpublished). This tephric complex is the result of an eruption beginning with a single magma phase that was trachyandesitic basaltic in nature (CF1a), then continued with a mix of trachyandesitic basaltic and trachyandesitic magmas, from which derives the presence of the two scorias facies in CF1b (figure 4). Only Puy de la Nugère has provided lavas where one observes all stages of two mix magmas during an eruptive phase with a compatible age (Gourgaud & Camus, 1984). This tephric complex is dated by ^{14}C on the underlying paleosols (Ly 338/ AA-22073 = 11990 ± 90 and ARC 1697 = 11460 ± 90) and directly on organic fragments within the tephra (Gif TAN 91102 = 12010 ±150 BP). The Les Roches Tephra has directly affected a Late Magdalenian living site, Abri Durif at Enval, 30 km to the southeast of its source (Vernet, 1992 ; Vernet & Raynal, 1995) : the uppermost layer is composed of a thin, regular, well-sorted fall (2cm thick) which adheres to the stone artefacts and faunal remains of the most recent Magdalenian occupation and thus seals the archaeological sequence.

3 - *La Moutade Tephra* is a black coarse ash with a basaltic trachyandesite composition seen at a number of locations in the western Limagne (Orange Marsh, Sardon valley and Villeneuve-les-Cerfs Marsh) (figure 5). The mineralogical association is clearly dominated by brown amphiboles (70

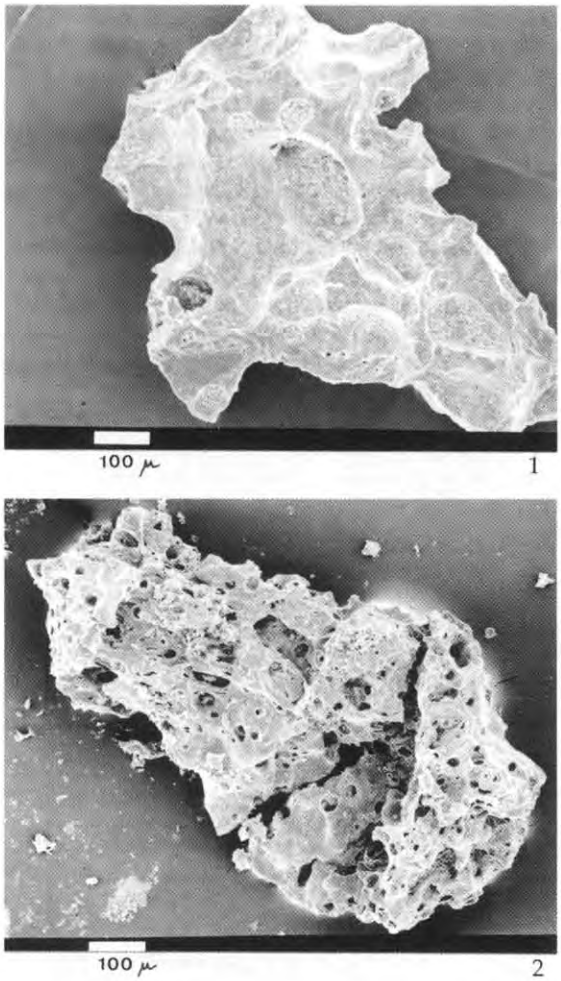

Figure 4: *MEB observation of the two different types of scorias in CF1b Tephra (see text).*

to 85%). Puy de la Nugère is proposed as the source (Etlicher *et al.* , 1987 ; Juvigné *et al.*, 1991). Direct dating has been obtained by thermoluminescence at 13700 ± 1700 (Cler TL 110), palynologic dating indicates the Alleröd and radiocarbon dating is 11360 ± 130 BP (Ly 3733) (Vernet and Paquereau, 1986, 1991 ; Vernet *et al.* , 1990). Its impact on the vegetation has been evidenced by the palynology on the Villeneuve-les-Cerfs site (Raynal *et al.*, 1998).

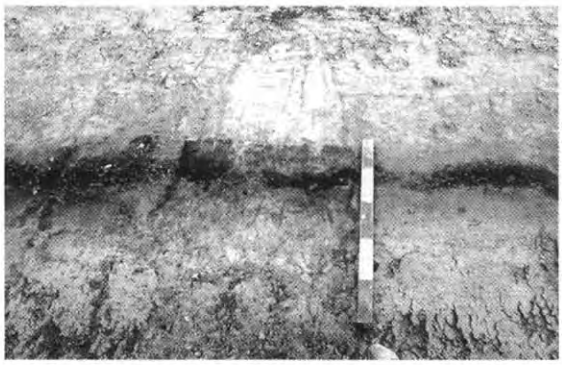

Figure 5: *La Moutade Tephra within Alleröd palaeosoil at La Moutade I (photo G. Vernet).*

4 - The *CF2 Tephra* (or Descartes Street fallout). This occurs in centimetric light grey beds with numerous xenoclastes incorporated from the bedrock (figure 6) which lie in unconformity above CF1. It has a composition of basaltic trachyandesite and characteristic minerals are green clinopyroxene and brown amphibole. It is present in several places in the Clermont Basin, at Descartes Street, Sous-les-Vignes Street, Blanzat Street and Montjuzet Street. Dated directly by TL at 8700 ± 900 (Cler 114) (Raynal *et al.*, 1989) and dated by palynology on another section near Clermont to the Pre-Boreal/Boreal boundary (Vernet *et al.*, 1996 ; Raynal *et al.*, 1998).

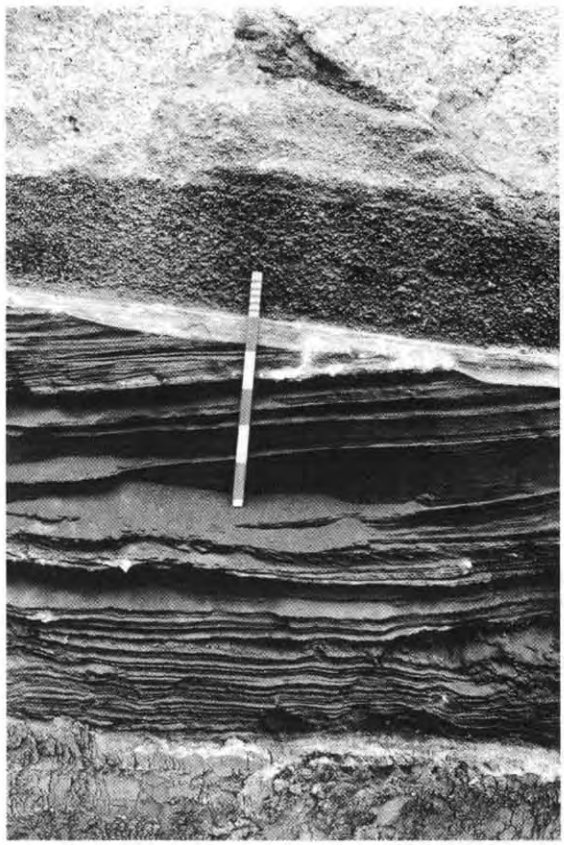

Figure 6: *succession of trachyandesitic tephras in Clermont area, Rue de Montjuzet section. From bottom to top : CF1, CF2, CF3 and CF4 (photo G. Vernet).*

5 - The *CF3 Tephra* (or Montjuzet Street fallout). This has a composition of trachybasalt, with characteristic minerals being green clinopyroxene and olivine. It is present in all the studied stratigraphies of the Clermont Basin and in the Cebazat-Gerzat area. It presents a very characteritic facies : at the bottom a thin reddish level typical of a phreatomagmatic *blast* effect, then a mix of products characteristic of a mixed eruption (magmatic and phreatomagmatic), finally vesicular scorias characteristic of a strombolian plume fall (Vernet, 1992) (figure 7). These tephras are dated to the Boreal by palynology (Vernet *et al.*, 1996). For now their origin remains uncertain.

6 - The *CF4 Tephra* (or Blanzat Street ancient fallout), is composed of basaltic trachyandesite with characteristic minerals being clinopyroxene and olivine. Its facies is an alternation of beds rich in vesiculated scorias and beds of finer granulometry rich in xenoclasts of the bedrock and cracked marl fragments (strongly phreatomagmatic

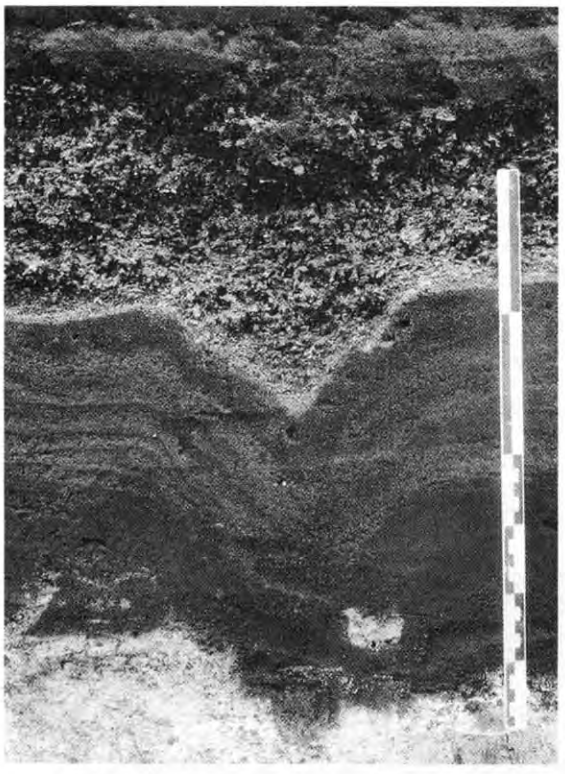

Figure 7: *succession of trachyandesitic tephras in Clermont area. From bottom to top: CF1a, CF1b and CF3 divided in two parts: thin blast layer at the bottom and Strombolian fall at the top (photo G. Vernet).sion*

characteristics). They are present at Blanzat Street and Montjuzet Street (figure 6). Their chronological position is identical to that of CF3, at the limit of the Preboreal/ Boreal (Vernet et *al.*, 1996). The origin is uncertain but one can suppose that they come from the same structure as CF3.

7 - The *CF5 Tephra* (or Sous-les-Vignes Street fallout), is a coarse ash forming a centimetric lamina (0.03m) discontinuous, cream to pastel rose, with a composition of rhyolite (figure 1), with characteristic minerals being green clinopyroxene (55%), zircon (16%), brown amphibole (14%) and apatite (10%). This lamina is present in a few stratigraphies in the Clermont Basin (Sous-les-Vignes Street) and in the Limagne near Gerzat (Daugas et Tixier, 1975 ; Juvigné *et al.*, 1992 ; Raynal *et al.*, 1998). It is dated palynologically at the Boreal/Atlantic limit (Vernet *et al.*, 1996). The Kilian Crater has been proposed as source volcano (Vernet, 1992) after the lack of sphene which excludes the Puy Chopine (Bentor, 1955) and the stratigraphic position which excludes the Puy de Dôme, older after the TL dates (Faïn *et al.*, 1986, 1991). But the Puy Vasset is a potential source (Michon, 1996). A very broad dispersal has been proposed for the trachytic tephras of the Chaîne des Puys (Puy de Vasset or Kilian Crater) of Boreal age (Juvigné, 1991, 1992).

8 - The *Marsat Formation*, eruptive and epi-eruptive born of a trachytic structure, formed of a mud-flow, torrential alluviums and ash levels, overlays two epipalaeolitic archaeological layers dicovered at les Pradelles in 1995 (Vernet *et al*, 2001). The geochemistry lies on the trachyte/ rhyolite limit (figure 1) and the mineralogy of these products (presence of sphene) allows them to be sourced without ambiguity to the Puy Chopine, more than 11 km distant. Carbonized branches, discovered at the base of eruptive products of this volcano in proximal position (approximately 1 km from the protrusion), have given a radiocarbon age of 8464 ± 70 BP, confirming previous results (Camus 1975, Raynal *et al.* 1981, Juvigné 1987). The importance and the nature of eruptive deposits from the Puy Chopine discovered at Marsat radically change the vision that one had until now of trachytic eruptions in the Chaîne des Puys : a syneruptive mud-flow hit the Limagne more than 11 km from its emission point around 8500 year BP.

9 - The *CF6 Tephra* (Blanzat Street recent fallout), shows bedded levels with a fine granulometry where alternate dark and pale beds, rich in xenoclastes, composed of trachyandesite. Characteristic minerals are green and brown clinopyroxenes. It has only been observed in one place of the Clermont Basin (Blanzat Street) (figure 8) but could also have been present in the Gerzat area. The source volcano is doubtless the Puy de Pariou (Vernet, 1992), relating particularly to the main lava flow episode in the history of this volcano dated of 8180 ± 810 (Guérin, 1983).

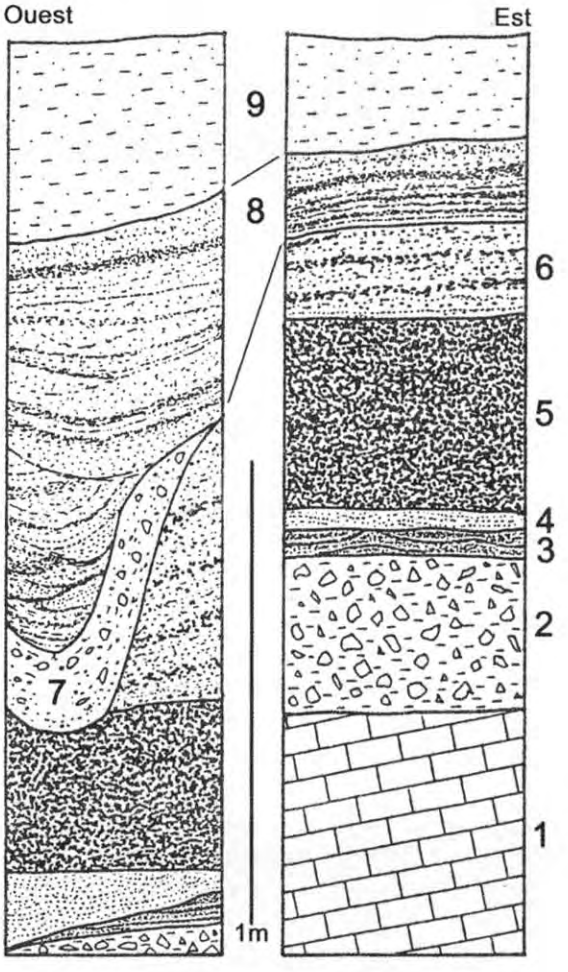

Figure 8: *rue de Blanzat section. 1: Oligocene marls. 2: Diamicton. 3: CF1 tephra. 4: CF2 tephra. 5: CF3 tephra. 6: CF4 tephra. 7: Ancient colluvium. 8: CF6 tephra. 9: Recent colluvium.*

10 - The *CF7 Tephra* is represented by centimetric angular fragments of trachyte (figure 9) noticed on several sections studied in the North-east, in the East and the South of Clermont-Ferrand, above the CF6 fallout and below an Ancient Neolithic archaeological layer (^{14}C ETH-17946 = 5405 ± 75 BP). The sole trachytic structure with lava possessing comparable contents is the Puy de Clierzou. The content analysis of radioelements ^{232}Th and ^{214}U confirms this origin (Miallier, pers. com). The morphology of trachytic fragments suggests that they come from the crust of a dome. They are therefore distal evidences of a primitive dome explosion of the Puy de Clierzou and form the more recent tephric covering in the Limagne.

Figure 9: *CF7 Tephra angular fragments of trachyte sampled in different locations of Western Limagne (photo G. Vernet).*

11 - Other Tephras - Two tephras of unknown origin are still to be dated precisely : the *Gimeaux Upper Tephra,* with a trachyandesitic composition, deposited during the Late-Glacial *sensu lato*, and the*Rouzat Upper Tephra*, composed of trachybasalt, probably deposited at the beginning of the Holocene (Vernet, 1992).

12 - Conclusions - Late Glacial and Holocene volcanic activity of the Chaîne des Puys had a severe impact on the Limagne plain, especially during the Alleröd and the Boreal : there are no paleosoils between tephras CF2, CF3 and CF4, which are followed by several trachytic volcanic products leading up to the beginning of Neolithic times. Other more recent tephras have been observed on the Dômes plateau (Juvigné *et al*, 1986) but have not been recognized in the plain. Tephras have been preserved in various depositional contexts and have contributed to filling the Limagne hollows and greatly disturbing their regular evolution. A detailed tephrostratigraphic framework has thus been established. Archaeologists have now to determine precisely the consequences for prehistoric human groups.

Aknowledgements: this work was funded by Région Aquitaine and Région Auvergne within the *Espaces volcaniques préhistoriques* project of GDR 1122 CNRS *Hommes et volcans avant l'Histoire*. Authors particularly thank Guy Camus and dedicate this work to his memory.

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